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Quantitative Variations of the Zooplankton in Norwegian Coastal and Offshore Waters during the Years 1949—56

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INTRODUCTION

The author has previously (1954, 1955) reported on the quantitative and qualitative variations of the zooplankton in Norwegian coastal waters and in the Norwegian Sea. The present paper is an extended report on the quantitative variations in the same areas (Fig. 1) during 1949–56.

At the permanent coastal stations vertical hauls with a 70 cm Nansen net (mesh size .2 mm) have as a rule been taken from the bottom to the surface and from 50 m to the surface weekly or fortnightly.

At station M a full series of hauls from 2000 m to the surface has been taken monthly, 100–0 m and 25–0 m hauls each week. Half hour's horizontal hauls at the surface with a metre egg net have been taken weekly.

Clarke-Bumpus plankton samplers have been used each spring in the coastal waters of northern Norway, and some vertical hauls were taken with a metre egg net on the Helgeland banks in March 1955.

The plankton samples were preserved in 4–6 % formalin, and the volumes determined by draining (Wiborg 1954).

For each locality monthly mean volumes have been calculated for the period 1949–56.

THE PERMANENT STATIONS

At Sognesjøen (Fig. 2) the spring increase starts in March, and reaches maximum in April. The volume then drops slightly to August, with a second peak in September. From October to March the volume is below 2 ml. The variations in the upper 50 m are similar to those of the total water column, but there is no peak in September.

The figures for the months April to August show some deviations from the mean from one year to another. In 1952–53 the April volumes were above the mean, in 1954–55 below the mean (Fig. 3).

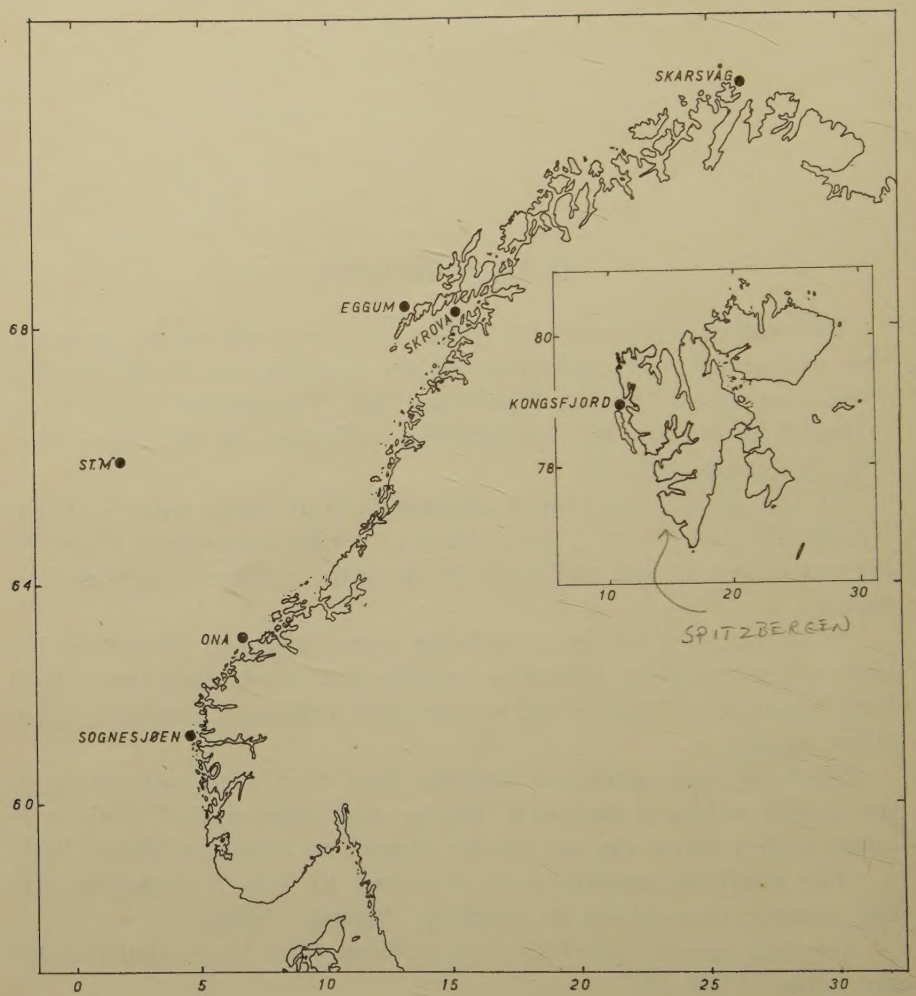

Fig. 1. Permanent zooplankton stations 1949—56.

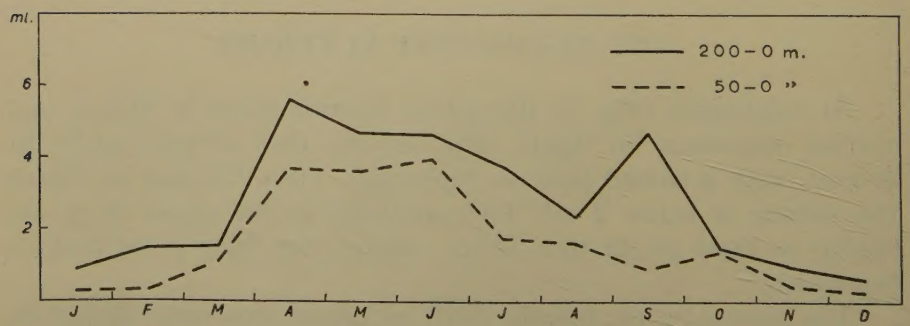

Fig. 2. Variations in plankton volume at Sognesjøen. Monthly mean figures 1949—56. Nansen net hauls.

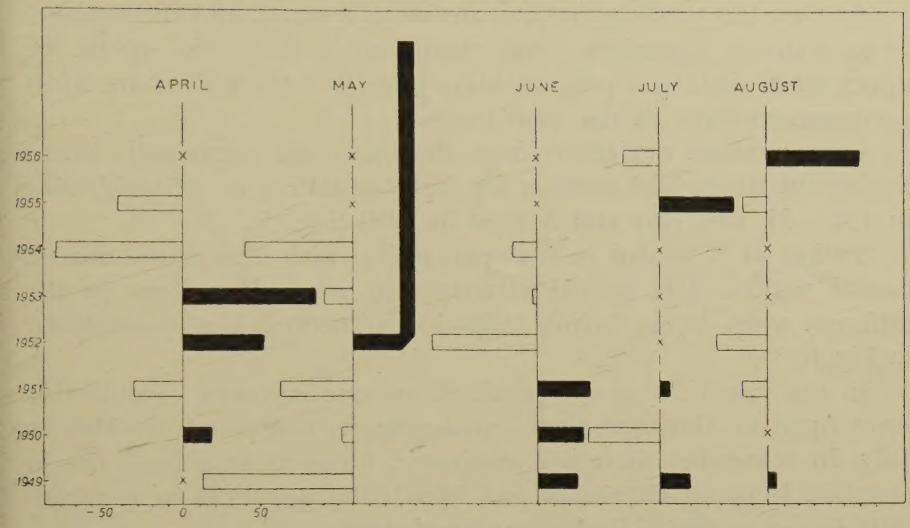

Fig. 3. Percentage deviations from the mean plankton volume at Sognesjøen during April—August 1949—56. Black columns: positive figures, open columns: negative figures. x — no hauls.

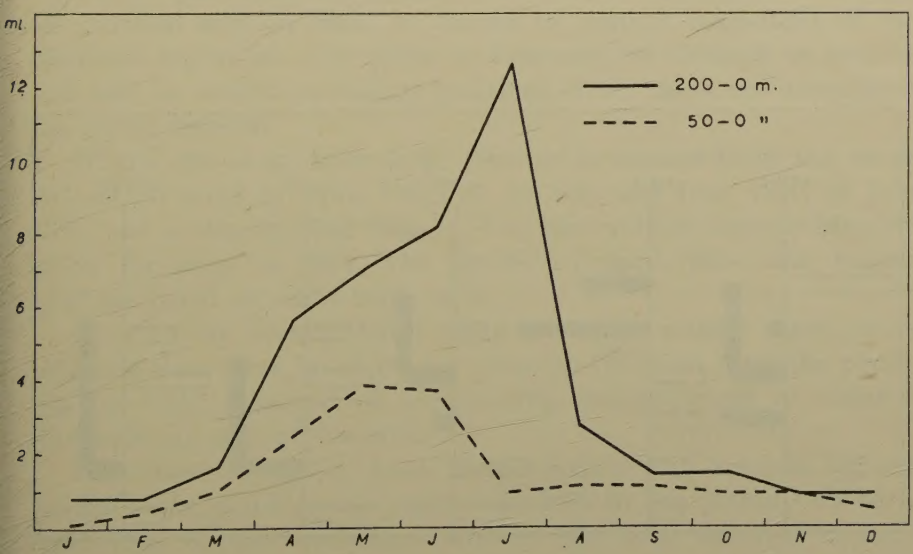

Fig. 4. Variations in plankton volume at Ona. Monthly mean figures 1949—54. Nansen net hauls.

At Ona the yearly variations are more marked, and the volumes larger than at Sognesjøen, with maximum in July (Fig. 4). In the upper 50 m there is a peak in May—June, but the figures are small compared to those of the total hauls.

Large positive deviations from the mean are occasionally found during the spring and summer for April and June in 1951—52, May in 1953—54, and July and August in 1950 (Fig. 5).

Station M is located in the open ocean, with Ona as the nearest coastal station. The annual variations in plankton volume in the different water layers during 1950—56 (Nansen net hauls) are shown in Fig. 6.

In the upper 25 m the plankton volume increases considerably from April to May, and then remains nearly constant from May to July. In September there is a minimum, followed by a small rise in October. Between December and March the upper 25 m is practically free of plankton in daytime (see below).

In the 100—0 m layer the figures are much higher, with a pronounced peak in June, a minimum in September, and a very small rise in October.

In the 600—100 m layer there is a basic plankton population of about 7 ml, and the curve is more varied than in the surface layers. The peaks in March and May are probably related to upward migrations of the wintering stock, and the peak in October to plankton organisms migrating into the deeper layers for wintering.

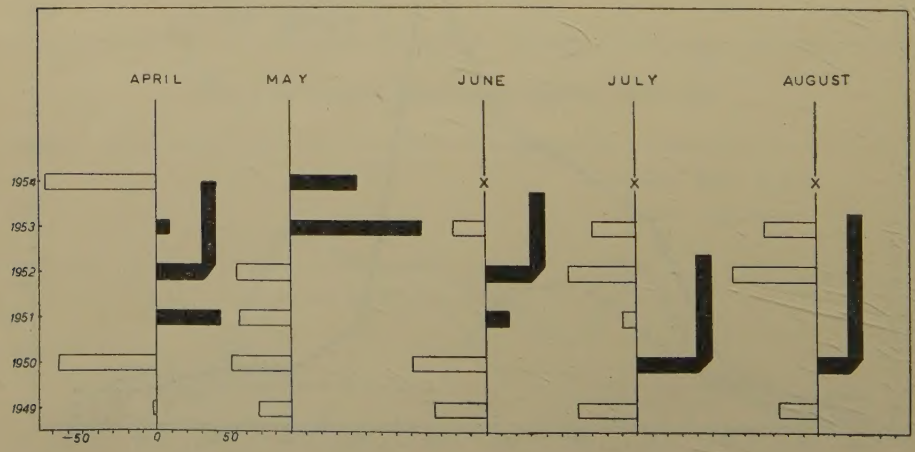

Fig. 5. Percentage deviations from the mean plankton volume at Ona during April—August 1949—54. Symbols as in Fig. 3.

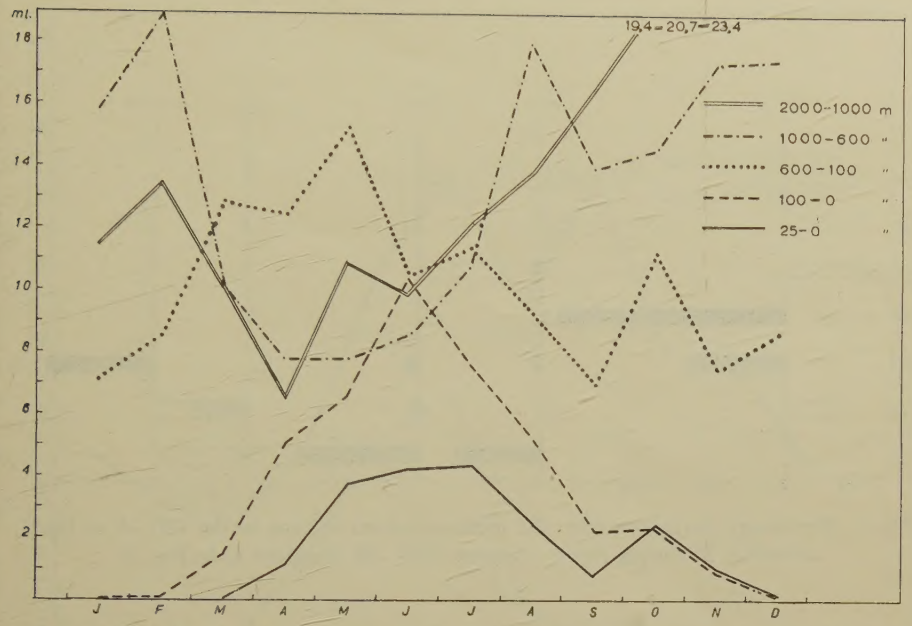

Fig. 6. Variations in plankton volume at station M. Monthly mean figures 1950—56. Nansen net hauls.

In the 1000—600 m and 2000—1000 m layers the basic populations are of the same size as in the 600—100 m, but the yearly variations are reverse to those in the upper layers, with minimum in April, and increasing quantities of plankton from May to December. This kind of variation may in main be caused by vertical migrations of the plankton organisms. The peaks in February are difficult to explain and may be related to shifting positions of the ships, or caused by a too scanty material.

In the 100—0 m layer large positive deviations from the mean volume occurred in April 1952—53, in May and June 1950, in July 1951, and in August 1952 (Fig. 7). The June volume was considerably below the mean in 1954. The figures for April, June, and August 1953 are based on night hauls only.

In 1953—54 vertical hauls taken by night yielded much more plankton than those taken by day (Wiborg 1955). In April the plankton by night consisted of prespawning concentrations of *Calanus finmarchicus* and euphausiids.

Half-hour's horizontal hauls at the surface with a metre egg net yielded more plankton by night, especially in the period October—April (Fig. 8). In September—October 1955 large numbers of salps rendered volume measurements impossible.

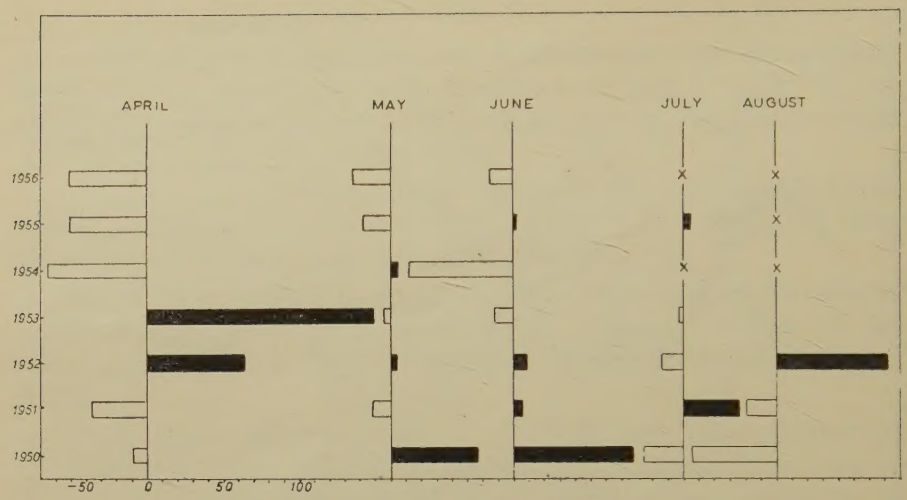

Fig. 7. Percentage deviations from the mean plankton volume in the 100—0 m layer at station M during April—August 1950—56. Symbols as in Fig. 3.

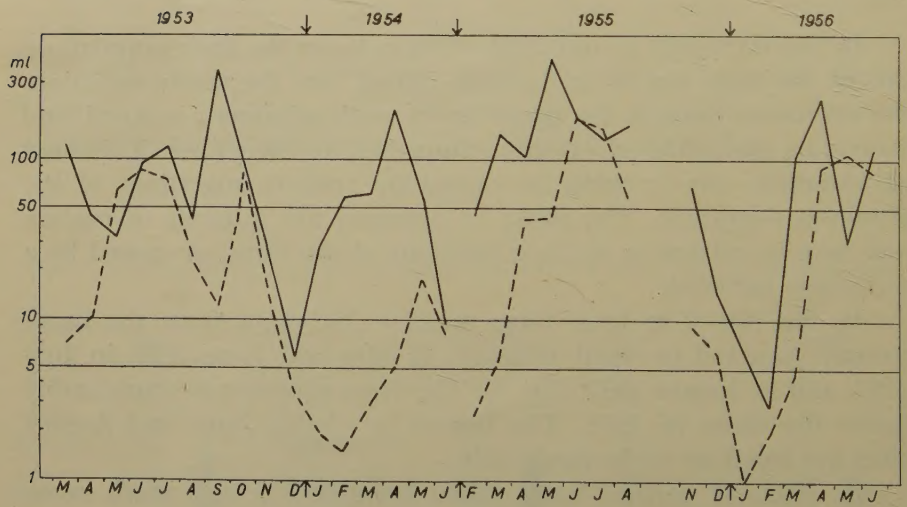

Fig. 8. Variations in plankton volume at day (broken line) and night (continuous line) in horizontal surface hauls with a metre egg net at station M in 1953—56, adjusted to 1 hour's haul. Monthly mean figures and logarithmic scale.

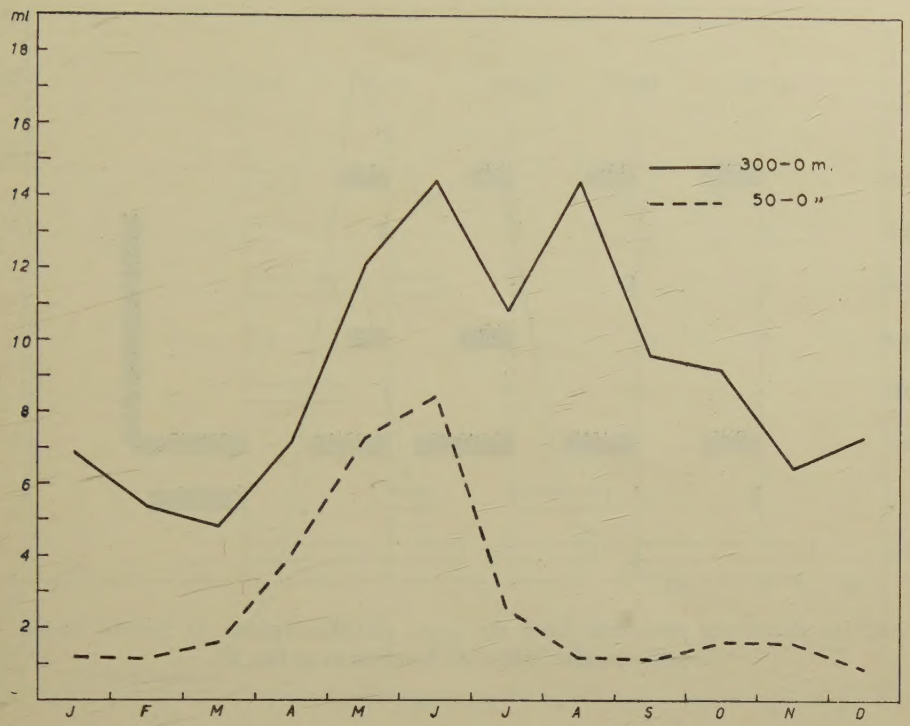

Fig. 9. Variations in plankton volume at Skrova. Monthly mean figures 1949—56. Nansen net hauls.

The permanent station at Skrova in the inner part of the Vestfjord in northern Norway is a typical fjord station with peaks of plankton in June and August and minimum in March (Fig. 9). The minimum stock of plankton, 5—6 ml, is much larger than at Ona (1 ml). The difference between the largest and smallest average volume of plankton amounts to 7—9 ml.

In the upper 50 m there is only one peak, in June, and below 2 ml of plankton from August to March. The difference between maximum and minimum quantity of plankton is nearly the same as for the total water column. Notable quantities are only found from April to July.

In September and October 1953 large numbers of *Aglantha digitale* increased the plankton volumes considerably, and at the same time in 1955 *salps* disturbed the picture. These organisms were picked out and excluded from the volume measurements.

In 1951 there were positive deviations from the mean volumes, especially in August (Fig. 10).

At Eggum on the outer side of the Lofoten islands data are only

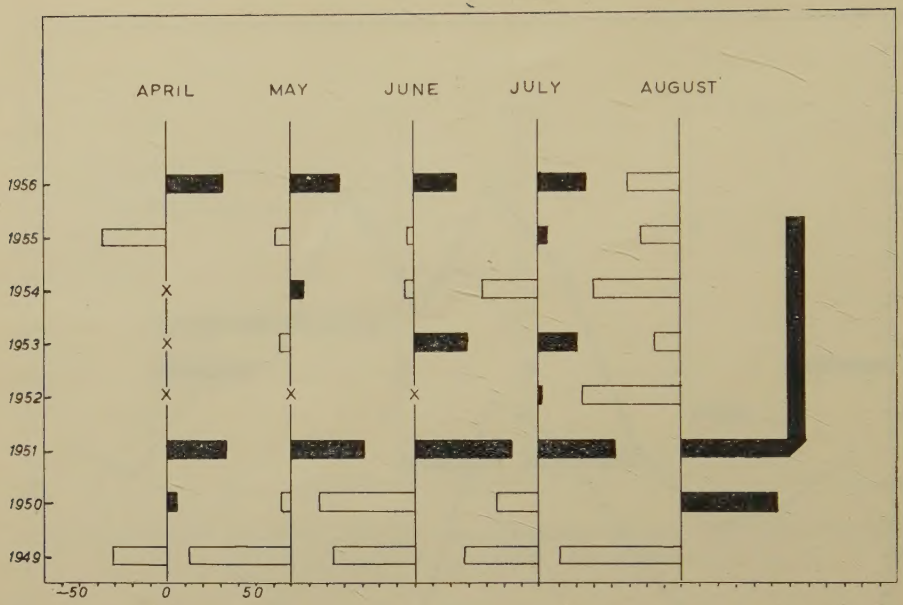

Fig. 10. Percentage deviations from the mean plankton volume at Skrova during April—August 1949—56. Symbols as in Fig. 3.

available for the years 1949–1954. During spring and summer the plankton volumes are very large, with peaks of 36 and 30 ml in May and July respectively (Fig. 11). In the upper 50 m the plankton is very abundant, with a peak of 26 ml in May. From December to March plankton is scanty in all water layers.

In October 1953 large numbers of *Pleurobrachia pileus* occurred. They were not included in the volume measurements.

The different months show large deviations from one year to another, with positive deviations in May 1950, June 1950–51 and July 1951.

At Skarsvåg, near North Cape, plankton sampling started in March 1955. In that year the summer maximum occurred in the middle of July, and the plankton volume decreased gradually to September, followed by a steep drop in October (Fig. 13). In the upper 50 m the decrease started already after July, but the volume increased a little in September and October.

In 1956 the yearly cycle was similar, but the summer maximum occurred earlier, at the end of June, followed by a minimum at the end of July, and a second peak at the beginning of September. In the upper 50 m the second maximum occurred in the middle of August.

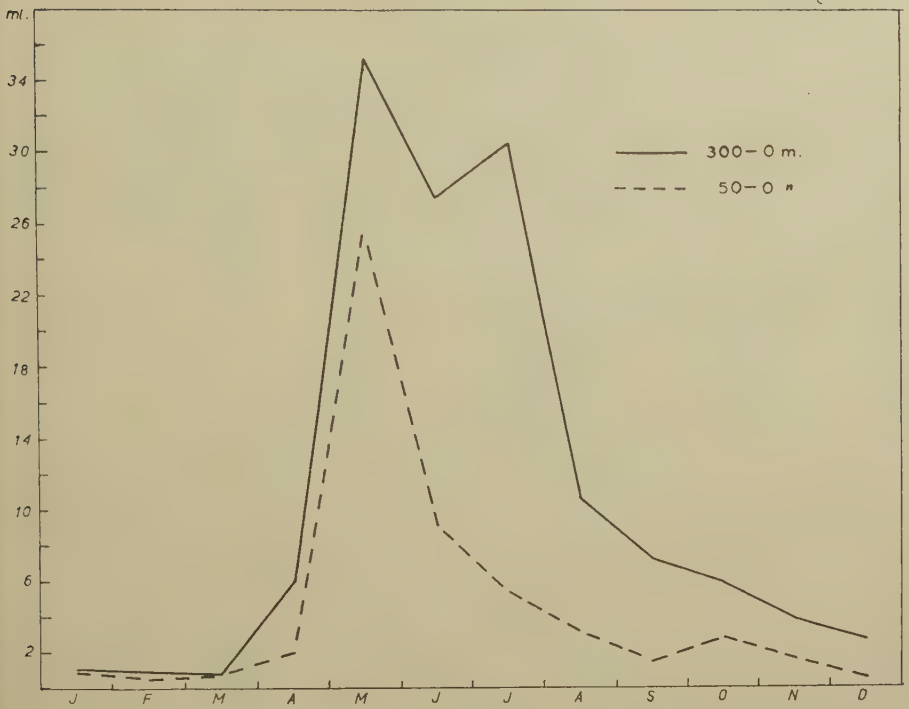

Fig. 11. Variations in plankton volume at Eggum. Monthly mean figures 1949—54. Nansen net hauls.

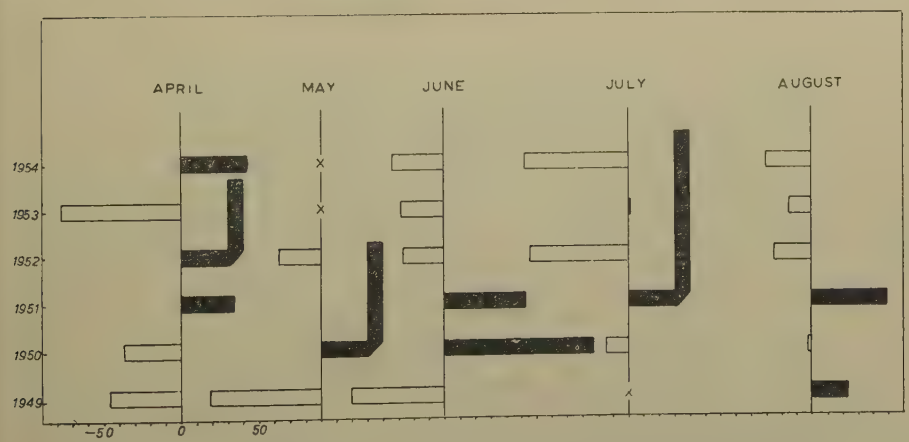

Fig. 12. Percentage deviations from the mean plankton volume at Eggum during April—August 1949—54. Symbols as in Fig. 3.

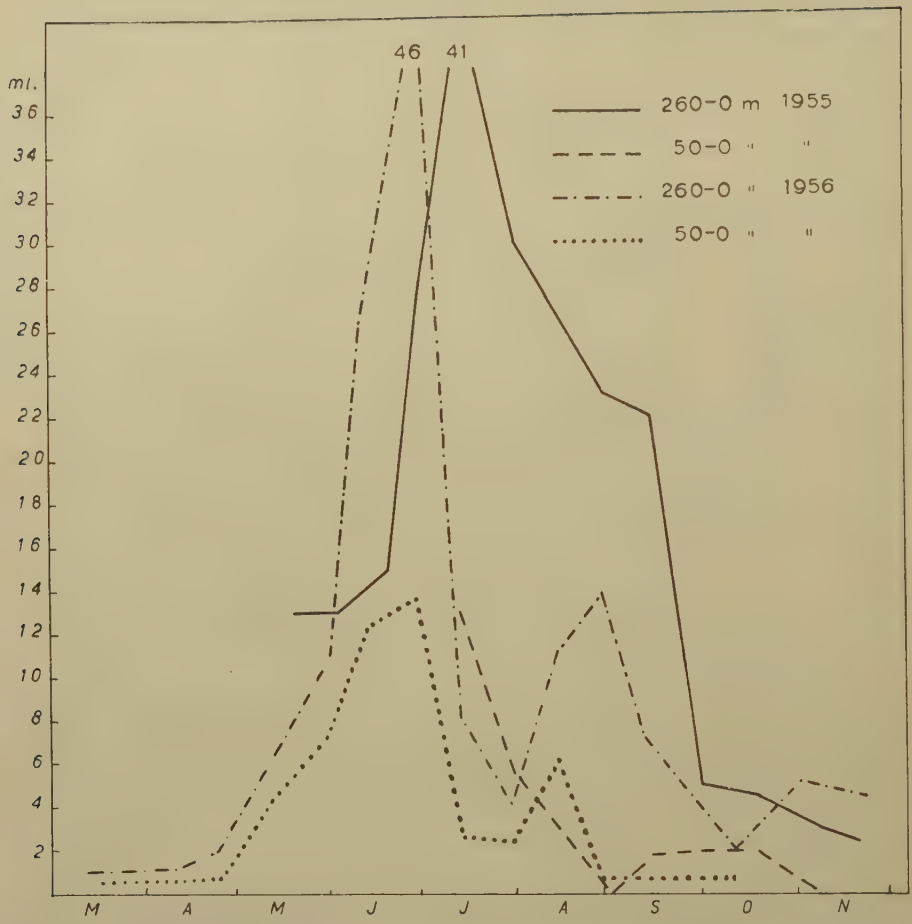

Fig. 13. Variations in plankton volume at Skarsvåg 1955—56. Nansen net hauls.

The plankton at Skarsvåg was dominated by *Calanus finmarchicus,* in the autumn also by euphausiids and *Limacina retroversa.* A few salps were found at the end of September 1955.

A permanent station was established in the Kongsfjord on the west coast of Spitzbergen in the autumn of 1956. The plankton volumes during 1956 are shown below:

Date	50—0 m	300—0 m
14. VIII	16.0 ml	—
25. VIII	96.0 ml	—
9. IX	7.0 ml	20.0 ml
25. IX	4.2 ml	37.0 ml
12. X	2.2 ml	30.0 ml

There is apparently a peak in volume at the end of August. *Calanus finmarchicus* was the dominating organism.

In order to compare the standing crop of plankton at the permanent stations, average figures have been worked out for the period April—August of the different years (Fig. 14). As plankton hauls are lacking for one or more months in some years, the figures are only partly comparable.

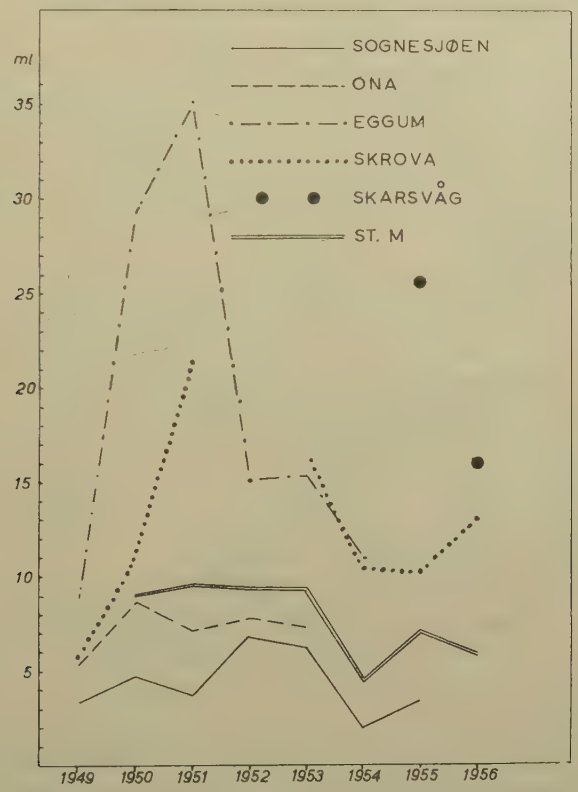

Fig. 14. Average plankton volumes at the permanent stations during the period April—August 1949—56.

At Sognesjøen, Ona and station M (the upper 100 m) the mean volumes range from 4 to 9 ml. There are maxima in 1950 and 1952—53, and a pronounced minimum in 1954.

Farther north, at Eggum and Skrova, the volumes are larger, 8—35 ml, with a very steep increase from 1949 to 1951, followed by a steady drop to 1955.

At Skarsvåg there is a drop from 1955 to 1956. The figures are of the same order of magnitude as at Eggum and Skrova.

OBSERVATIONS FROM CRUISES

At the Helgeland banks a series of vertical hauls was taken with a metre egg net at the end of March 1955, before the spring increase of the plankton had started (Fig. 15). In the southern area there was some plankton near the coast; but the middle and northern areas were poor, the plankton being mainly concentrated near the edge of the continental shelf.

During the years 1949–56 a large number of horizontal hauls were taken in the coastal waters of northern Norway. The Clarke-Bumpus plankton sampler (mesh size of the net .3 mm) was used, being towed in steps of 5 m interval between 75 m and the surface. The mean quantity of plankton per square metre of sea surface has been calculated for three areas, 1) the Vestfjord, 2) the banks outside the Lofoten and Vesterålen islands and 3) the Andfjord. The figures comprise two periods: the beginning of May, and the end of May / beginning of June (Fig. 16).

The curves for the Vestfjord have peaks in 1950, 1953 and 1956 during the first period. The figures for the permanent station at Skrova do not agree very well with these data. The mean volume for April increased somewhat from 1955 to 1956, and the May volume from 1950 to 1951, but for the other years there is no correlation. The cruises are probably not representative of the whole month, and the Skrova station may not be comparable with the Vestfjord as a whole.

On the outer banks the plankton was most abundant at the beginning of May in 1951 and 1955, and at the end of May in 1951. The agreement with the observations at Eggum is very poor, and the explanation may be the same as for Skrova and the Vestfjord.

In the Andfjord the variation in volume during the first cruise is similar to that of the Vestfjord, with peaks in 1950 and 1953. In 1953 the observations were taken one week later than usual. During the second cruise there was a large maximum in 1950.

During the spring and early summer the plankton is on an average less abundant in the Vestfjord than in the Andfjord and on the outer banks.

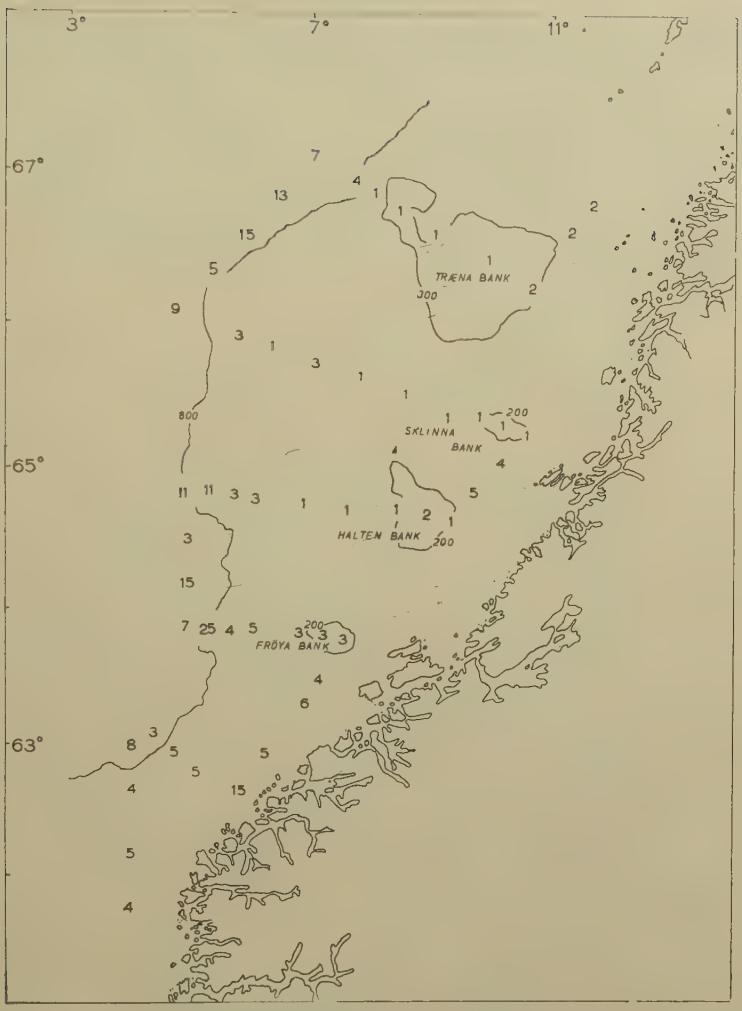

Fig. 15. Quantitative distribution of plankton (in ml) on the Helgeland banks 25—30 March 1955. Metre egg net, 200 m to surface.

There is some information on the quantitative variations of the zooplankton in adjacent areas. During the years 1949—56 the plankton in the Bear Island area was most abundant in 1949, 1950 and 1954 (Corlett 1953, 1958). In the second half of June, Pavshtiks (1956) found peaks of abundance in 1948, 1949 and 1954, but very little plankton in 1950, whereas the latter year was most successful for the plankton in a section across the Northcape current.

In the northern North Sea and North Atlantic the years 1950 and 1951 were favourable for the development of *Calanus finmarchicus,*

1952 and 1953 were medium years, 1954 and 1955 were unsuccessful, except between Scotland and Shetland, where *Calanus* was abundant in 1954 (Rae 1950–57).

In 1950, and partly also in 1951 and 1954, the zooplankton was

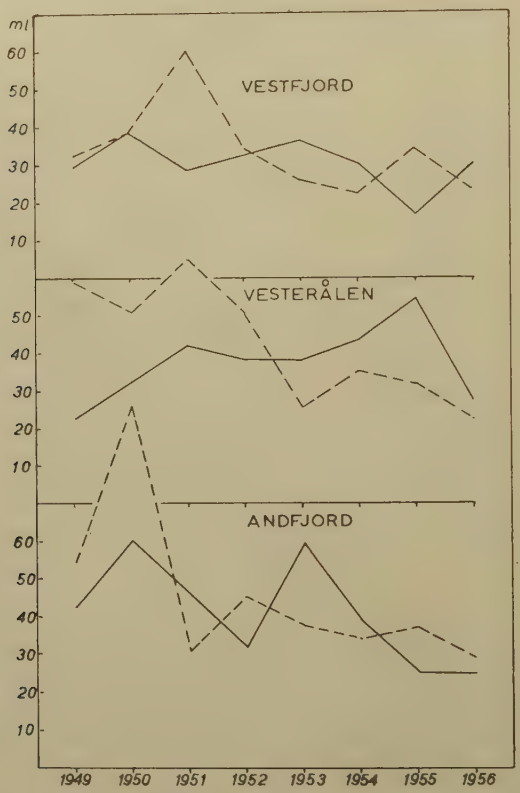

Fig. 16. Average quantities of plankton per square metre of sea surface in some coastal areas of northern Norway 1949—56. Continuous lines: beginning of May. Broken lines: end of May/beginning of June. Clarke-Bumpus plankton sampler hauls in steps of 5 m between 75 m and the surface.

evidently abundant over wide areas, whereas in the other years local variations were prevailing.

It is very difficult to have a well-founded theory as to the main causes of the fluctuations in the size of the standing crop of plankton.

I 1950 and 1954 the influx of Atlantic water on the Bear Island

banks and in the western Barents Sea was very strong (LEE 1952, LEE and HILL (in press), cited by CORLETT 1958). In these years the standing crop of plankton was highest in the Bear Island area (CORLETT 1958).

At the permanent stations along the Norwegian coast no clear relation has been found between the variations in size of the standing crop of plankton and the hydrographical conditions. This problem requires a closer study.

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